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STATE OF IDAHO
DEPARTMENT OF
ENVIRONMENTAL QUALITY

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Dirk Kempthorne, Governor
C. Stephen Allred, Director

August 1, 2001

Warren Bergholz, Deputy Manager
U.S. Department of Energy
Idaho Operations Office
850 Energy Dr.
Idaho Falls, ID 83401

Dear Mr. Bergholz:

On April 4, 2001, DOE management indicated to Idaho DEQ Director Steve Allred that DOE was reviewing its requirements for retrieval in the Subsurface Disposal Area to determine to what extent there was flexibility to reduce Pit 9 project time and cost. Idaho DEQ thought it prudent to obtain an independent analysis of the requirements for the 90% Pit 9 design, and contracted with Auxier and Associates in May.

Although DOE has not provided DEQ with a critical review of the application of DOE's requirements, I am enclosing a copy of the recently issued Auxier and Associates report for your information.

Sincerely,

Orville D. Green

Orville D. Green
Administrator
Waste Management & Remediation Division

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cc: Steve Allred, DEQ Director (w/o encl.)
Kathleen Trever, INEEL Oversight Program (w/o encl.)
Ann Williamson, EPA (w/ encl.)
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REPORT OF JOSEPH L. ALVAREZ, Ph.D., CHP AND JOHN A. AUXIER, Ph.D., CHP REGARDING WASTE RETRIEVAL FROM PIT 9, THE 90% DESIGN

July 25, 2001

Prepared for:
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Waste Retrieval from Pit 9
Review of the Stage II 90% Design

1. Executive Summary

The Pit 9 Stage II 90% Design is a modular system that includes excavation, handling, examination, and packaging of the Pit 9 waste. The module is a movable steel structure with HVAC and stack exhaust that was designed as though it were a permanent production facility. The design is in sharp contrast to methods used in prior excavations of Rocky Flats waste where minimal containment was used and no measurable contamination release was experienced. The design principles of Stage II are to meet maximum worst case on a continuous basis rather than containing the maximum credible case as the exception to normal conditions. A much simpler and cost effective design is possible with small, specialized modules that support the excavation rather than a large, single module that contains all aspects of the operation.

2. Introduction

The record of decision (ROD) for the INEEL Operable Unit 7-10 or Pit 9 of the Radioactive Waste Management Complex determined that Pit 9 may present a current or potential threat to public health, welfare, or the environment by actual or threatened releases of hazardous substances from the Site. The remedy selected for Pit 9 was the reduction of the concentration and volume of radioactive and hazardous wastes in Pit 9. The components of the remedy are

> Excavation and segregation of waste with greater than 10 nCi g^{-1} TRU elements for input to the treatment process;
>
> Treatment of waste using chemical extraction, physical separation, and or stabilization to remove radionuclides and hazardous constituents and to reduce the toxicity, mobility, and/or volume of those wastes that remain;
>
> Treatment of listed hazardous wastes to levels which will allow for delisting of the waste (for material returned to the pit) in accordance with the RCRA and Idaho HWMA;
>
> Return of treated materials to Pit 9 (treated materials will contain less than or equal to 10 nCi g^{-1} TRU elements and meet regulatory standards for hazardous substances of concern;
>
> Volume reduction by approximately 90% (for material undergoing treatment); and
>
> Onsite storage of concentrated waste residuals in accordance with ARARs until final disposal.

The ROD was addressed as a three-stage plan based on a 1997 SOW. Stage I is complete and was the subsurface investigation via bore holes of Pit 9 for the siting and design of Stage II. Stage II is the design, construction, and retrieval of waste and soils from a selected portion of Pit 9 for characterization and treatability studies. The 90% design is complete for Stage II. Stage III is the complete remediation of Pit 9 based upon information from Stage II and any subsequent redesign.

The 90% design for Stage II calls for a total project cost of $117,500,000 and requires three years to complete. The State of Idaho questioned the Stage II 90% design and asked Auxier & Associates (A&A) to evaluate the design assumptions for Pit 9, including the assumptions on which design input or design decisions were based. In addition, A&A was to perform an evaluation of DOE radiological requirements imposed on the Pit 9 project by the '90% design'. A&A was to prepare an assessment of the impact of specific DOE requirements that contributed to significant portions of the cost of Pit 9 excavation that may have been a result of overly-conservative design assumptions or design decisions. A&A was to perform the evaluation and assessment by reviewing the current DOE proposed design and a review of the relevant state, federal, and DOE safety and environmental requirements for excavation and retrieval of radioactive wastes and for shipping and storage of wastes at permanent waste disposal sites. The evaluation was to estimate the personnel and environmental impacts of the waste retrieval from Pit 9 for comparison to the DOE proposed design and assumptions and relevant regulations.

A&A reviewed the Stage II 90% Design documents and found them cumbersome and difficult to relate to the project and project requirements. There is no summarizing document that shows in simple, straight forward terms the objective and requirements of Stage II. Within the many documents there is little or no indication of where or how each document fits into the final design. A comprehensive report of the review of the Stage II 90% design would be unnecessarily lengthy, as so much of the design itself is unnecessary. It would have been useful if the waste, risks, and objectives had been analyzed in a linear fashion following the expected process flow and each problem addressed in turn with the solution.

3. Analytical and Historical Data

Plutonium wastes from the Rocky Flats Plant were placed in Pit 9 of the RWMC from 1967 to 1969. These wastes were in 55 gal drums or cardboard or wooden boxes and some uncontained articles. The drums contained bulk wastes, while the boxes contained surface contaminated material such as empty drums. The drums were placed in the pit by dumping or stacking. The most of the waste in the drums was contained in double or triple plastic bag liners and some of the waste was individually bagged before placing in the liners. Damage to the dumped drums is expected. The soil placed around the drums for fill and over the drums is dry because of the desert conditions and little moisture penetrates to the drums during and after precipitation. Nevertheless, dry soil contains about 16 vol.% moisture so deterioration of the drums is expected and has been observed.

The contents of the drums vary, but there are 4 general classes of drums. The amount of plutonium varies from less than 10 nCi/g to a high of 125000 nCi/g of plutonium. The average content of a drum is 250 nCi/g. This amount of plutonium represents a large source term if dispersed. In general, dispersion is expected to be minimal because of the form of the material; consolidated material in plastic bags. Mechanical disturbance can penetrate the bags and break up the material. The potential for dispersal must be analyzed before methods of containment, protection, and monitoring are designed.

If the material were mechanically dispersed it could reach concentrations of 10 g/m^3 which is 2500 nCi/m^3. A puff that disperses uniformly to a 10-m radius will have a concentration of 1.2 nCi/m^3. This concentration is 300 DAC. This simple analysis shows that the potential for occupational exposures to high concentrations of plutonium exists, but does not indicate the potential for intake. If 1% of the mass is respirable (a reasonable value), the 10-m sphere concentration is 3 DAC. Time must be considered for the intake. If the concentration exists for 6 minutes then the intake is 3 x 0.1 / 2000 = 0.00015 DAC. If the operating conditions are such that a worker receives 3 such exposures per day, the annual dose is 560 mrem CEDE. This dose is greater than 100-mrem DOE limit (10 CFR 835) and since this is a scenario that could be expected under reasonable conditions of care then worker protection in the form of engineered controls or respiratory protection is required. Off-site exposure would be well less than 100 times lower so no additional measures are necessary for reducing the population dose.

A study was conducted in 1971 and reported by Thompson in 1972 (1) to determine the condition of buried Rocky Flats wastes and the problems associated with excavating and examining the waste. Deteriorated and leaking drums were found as well as damage to the drums and contents from dumping. Plywood and cardboard boxes were deteriorated but the plastic liners were generally intact. Little contamination spread was encountered during the handling even though plutonium had leaked from the drums, contaminating the soil. Winds of 20 mph did not measurably spread contamination. The study found that single layer anti-C clothing and respirators were sufficient to prevent personal and internal contamination. Simple containment of recovered material was sufficient to prevent contamination spread during handling and transport. Double bagging of dry material was the usual packaging mode and leaking materials were drummed.

The Thompson 1972 study found that a small backhoe was the most effective piece of equipment for uncovering drums if hand shoveling in the immediate vicinity of containers was employed.

A second study reported by McKinley in 1978 (2) was conducted to demonstrate the safe retrieval and repackaging of buried waste. The primary investigation was on stacked drums, but dumped drums and other types of wastes were probed by excavating pits and trenches. The stacked drums were retrieved with negligible spread of contamination, but other types of waste presented a potential for contamination spread using the techniques of the study (dozer, Drott excavator, and hand labor).

4. Regulatory Requirements

The regulatory requirements for Pit 9 are DOE directives regarding protection of workers, the public, and the environment. The requirements are found in Binder IV-A&B of the Stage II design package and will not be reviewed here. Many of the listed requirements are construction and facility requirements. This review focused on protection of personnel and the environment as found in 10 CFR 835, 40 CFR 61 (NESHAPS), and DOE Order 5400. Further requirements of importance are Waste Acceptance Criteria for WIPP and disposal at the INEEL. These were also not addressed except to consider handling of material for inspection, repackaging, and shipment.

5. Analysis of Data (risks) versus Regulatory Limits

a. Analysis of Criticality Potential

Work with fissile material requires a Criticality Safety Evaluation according to DOE Order 5480.24 and DOE-STD-3007-93, Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities. A Criticality Safety Evaluation could be precluded in the case of excavating Pit 9 because the material placed in the Pit conservatively met criticality standards at the time of placement. The likelihood of increasing the concentration is vanishingly remote, as is the possibility of increasing moderation or reflection to an unsafe degree. Nevertheless, a critical reevaluation is prudent. At least two such evaluations have been performed.

In 1999 the DOE established an Independent Technical Review Panel (ITRP) to evaluate the safety concerns associated with sonic drilling into Pit 9 (3). Though the ITRP's objective was the safety of sonic drilling, their analyses also serve a more general application. In its report, section 8.2, ITRP addressed criticality potential. The panel lists four conditions necessary to achieve criticality;

1. There must be a sufficient mass of fissile material.
2. The fissile material must be of a certain concentration.
3. The fissile material must have a specific geometry.
4. There must be a neutron moderating material.

As there has been no criticality, at least one of these criteria has not been met. Neglecting items 1.and 4., there would have to be some circumstance during excavation that would increase the concentration or improve the geometry of the plutonium, the fissile element of concern, for criticality to occur in the future. Further, the plutonium is chiefly in a nitrate matrix; nitrates are neutron absorbers, or poisons, for a critical assembly. Separation of the Pu and the nitrates is highly unlikely. Other plutonium is in graphite crucible remnants. Graphite crucibles are excellent neutron moderators and the Pu is in close proximity, i.e., on and in the surface, making the graphite crucibles the likely worse case for potential criticality. All the graphite waste was subcritical when placed in Pit 9, any disturbance of the graphite, such as breakage or scouring, would decrease the potential for criticality even further.

The "Nuclear Criticality Safety Guide"(4), gives a long list of the important parameters bearing on criticality, discusses them in greater length than the ITRP, and includes a discussion of the "Double Contingency Principle" of criticality safety. The double contingency principle requires two independent and unlikely events to occur concurrently to cause a criticality. In the case of pit 9, it is highly unlikely that any excavation could improve either the specific geometry or the concentration of any plutonium in any area. The ITRP concluded, page 23, "In fact, it is not likely that any of the conditions for criticality could be met as a result of drilling in the pit 9 waste". The sonic drilling disturbs the configuration by dispersing and mixing the plutonium, thereby reducing the potential for criticality. Excavation will cause more movement and dispersal than drilling so the conclusion by the ITRP holds for criticality safety during excavation.

A Preliminary Criticality Safety Evaluation (INEEL/EXT-2000-00690) was performed for Stage II excavation. This evaluation considered the likely configurations during excavation, repackaging, and analysis. These configurations were approximated as spheres with water reflection, the most favorable geometry for criticality, and found that more than 10 kg of isotopically pure Pu-239 in Pit 9 soil would be required for criticality. The evaluated configuration is very conservative for any possible configuration for the planned activities. The largest expected amount of plutonium according to the evaluation is less than 2 kg of plutonium. The evaluation shows that it is not possible to achieve a criticality with the buried materials during excavation, packaging, and analysis. Nevertheless, the report concluded that a limiting mass should be 510-g plutonium in any package. The 510-g limit is based on the optimum criticality configuration, plutonium in solution in a water reflected sphere. The report then used 380 g (75% of the optimum mass) as the Stage II package limit and required a fissile mass detector at the digface to control to this limit. The 380-g and digface monitoring recommendations from INEEL/EXT-2000-00690 are unnecessary and excessive since the report showed that a criticality was not possible under the planned methods and conditions. There is no need for these recommendations as a double contingency since neither configuration nor mass will limit the retrieval, handling, and storage of the Pit 9 wastes.

b. Analysis of Fire Potential

The ITRP also evaluated the potential for fire and explosions associated with sonic drilling. As the sonic drill represented a potential source of ignition for fire or explosion, the conclusions reached by ITRP provide a safe upper bound for excavation of wastes. The ITRP concluded, page 24, that the potential for fire, even with the drill, was extremely unlikely. Given that any reasonable protocol for excavation must include work-face water misting to minimize dust, the potential for fire is extremely unlikely. Of course, a monitored work-face is attended during operations and fire extinguishing equipment readily available.

c. Analysis of Personnel Exposure potential for typical remediation techniques

The contents of the drums have the potential of reaching air concentrations of 3000 DAC or greater. The annual limit to a worker could be reached in less than an hour exposure at this concentration. Such an actual exposure and subsequent intake is highly unlikely because the level of dust would be nearly suffocating and the majority of the mass would not be respirable. Nevertheless, there is a potential for much lower concentration for extended periods that could result in intakes exceeding the annual limit. Well-controlled working conditions and methods can still result in unforeseen circumstances that could produce high concentrations in a short time (breaching a container of dry, electrostatic material) and cause intakes below the annual limit but well above 100 mrem CEDE.

The release potential calculated in EDF-ER-WAG-109 for the unabated case was 170 mrem for the offsite MEI. The MEI dose was calculated based on heavy dusting conditions of 0.5-g m^{-3} and full time operation. The operations are expected to be deliberate and methodical, which would have dusting approximately 1000 times lower (5) occurring for about one-third of the time. This more reasonable estimation of the source term reduces the MEI dose well below the NESHAPS 10-mrem limit and the 0.1-mrem requirement for monitoring and the 10 CFR 835 limits for worker protection. Further consideration of the conservatism of EDF-ER-WAG7-109 shows that the doses will be even lower and only rudimentary protective measures are necessary for normal operations.

Activity concentrations in the retrieval area were calculated in EDF-ER-041. This document showed that a potential for short-term concentrations of more than 20,000 DAC were possible but highly improbable (beyond extremely unlikely). Nevertheless should such an event occur, a system of roughing and HEPA filters could control the release sufficiently to protect nearby workers. EDF-ER-041 showed that a careful mode of excavation should result in very little airborne release. EDF-ER-041 used very conservative conditions and showed that the assumed dust loading of 0.55-g m^{-1} (similar to the assumption of EDF-ER-WAG-109) was easily conservative by about a factor of 1000 for the expected excavation methods. The large releases estimated by EDF-ER-041 required large activity loading of the waste and dropping of the waste from a height of 2 m. Most of the estimated release is the result of very conservative assumptions, but does suggest a need for monitoring the contents of the waste and requiring procedures tailored to the activity of the waste.

The retrieval study reports (Thompson 1972, McKinley 1978) showed that retrieval is possible with little contamination spread. Improved methods for handling waste during excavation and retrieval such as misting and local vacuuming should further reduce the release of contamination to the worker-breathing zone. Anti-contamination clothing and breathing protection will minimize intakes from releases and alarming monitors will limit the time of exposure to any releases.

6. Evaluation of Stage II Remediation Approach versus Risk Based Needs for Personnel and the local environment

The risks to the environment and personnel as calculated in EDF-ER-041 are based on unrealistic worst-case conditions. The conditions are appropriate for screening level assessments. The analysis shows that protective measures need be considered. The preliminary analyses above in Section 3 and 5.c show that there is a potential for high concentrations that would be totally unacceptable if allowed to persist. The obvious step is to propose methods that will prevent not only the highest potential concentrations but to prevent contamination spread at the source. The approach used in Stage II is to minimize and prevent contamination spread and to contain releases as though they were at the maximum worst case on a continuous basis. The Stage II 90% is unacceptably conservative.

We will analyze the need for protective measures (design requirements) by proposing a possible approach to waste retrieval and developing protective measures as necessary. The starting point is no protective measures (no containment, protective clothing, or dust suppression measures). Protective measures are devised in a serial manner starting from the source and progressing to final containment. If the source is controlled so that no release occurs, no protective measures are strictly necessary. The source to be considered is not the total waste in Pit 9, but the single container that is being exhumed at the time and any surrounding, contaminated soil. If the exhuming is regularly accomplished without release of radioactive material or other contaminants and with minimal external radiation exposure to the workers then no additional protective measures are necessary. A deliberate and methodical method of excavation is therefore a protective measure because it prevents release and exposure. Deliberate and methodical retrieval is required since all materials in Pit 9 should be expected to have no rigid containment. The plywood and cardboard boxes have definitely deteriorated as reported in Thompson 1972 and McKinley 1978. The metal drums in those reports were mostly intact, but showed rusting that was dependent upon time in ground. It can be assumed that all but the thicker sections, rings and seams, have completely rusted. The deterioration leaves the waste contained by plastic bags, at best. The Thompson and McKinley projects showed that the waste can be retrieved using standard, but careful techniques without the release of radioactive materials or other contaminants. The approach to the dig can be like any other excavation that requires the excavated materials be not damaged. A digface can be established at the angle of repose requiring digface access either bottom up or top down with sufficient reach to span the waste zone.

Excavation after removal of the overburden can proceed by vacuuming to expose the waste volumes, plastic bags or miscellaneous objects that have not deteriorated. Vacuuming can be performed with a reach that keeps the worker out of the immediate zone of disturbance while drawing the disturbed material into a filtered container, thereby preventing a release to the environment. The vacuumed material can be continuously monitored for radioactive content to sort the clean material and moderately contaminated soil from the >10 nCi g^{-1} soil. This or a similar method of excavation is the first level protective measure, excavation with minimal disturbance of the source and control of the material when disturbed. All surfaces can be continuously misted to retard resuspension. Misting of the surface is a further protective measure since it reduces the chance of release by loose materials. Each piece of waste can be exposed as much as possible by the vacuuming without damaging the integrity of any containing plastic.

A requirement for Stage II and beyond was that all retrieval be done remotely (6). The waste contained in a plastic bag (double bagged and taped per specification) will be difficult to move remotely. The Stage II design discussed the deterioration of the drums but usually described the retrieval process in words and figures as the retrieval of intact drums. The lifting of the waste and emplacement into an overpack container can be quite difficult. The bags may weigh up to 750 lb. and have a very nonuniform weight distribution. The bags will likely be ruptured or weakened by radiation or chemicals.

Foaming with polyurethane or spraying with a quick-setting epoxy may stabilize the bags or loose waste allowing the waste to be contained in place for lifting. It will be necessary to support the waste while lifting and to contain it to prevent spilling. The waste can be scooped with a specially designed front-end loader that will prevent spilling as it lifts. The scooping and certainly the dumping of the waste into a container will likely cause suspension of material so provision for reducing the release should be make. One method is to place a reinforced bag in the scoop in a manner that will allow waste to be scooped into the bag and the bag drawn over the waste and closed with a zipper or other device. The bag can be placed in an overpack container using lifting loops on the bag. An overpack container can then be placed in a portable examination unit for identification and analysis. These methods of stabilization, lifting, and overpacking or similar methods are further protective measures that prevent release of the materials and exposure of personnel.

The discussion thus far considered methods of preventing or retarding releases. Analysis of these methods will indicate possible releases or contamination spread because of limitations in the methods or accidents during handling. Methods should be employed to restrict releases and contamination spread to the immediate area and to monitor any release and spread. Modular systems can be developed to both monitor and confine releases. These modules should be lightweight, skid-mounted units that are easy to deploy, decontaminate, and dispose of. Since the modules must allow ready access for excavation there may be considerable open areas surrounding the work volume; nevertheless, a properly designed work volume and monitoring system can be the first layer of containment.

An industrial grade storage tent of fire retardant material can enclose the work volume and allow access through an air lock. This tent offers not only further containment but further opportunity to monitor an control inadvertent releases beyond the immediate work module. A large portable fan or fans attached to the tent can ensure a small negative pressure on the tent. The fan output should be filtered and monitored. This tent would be the primary means of containment of the excavation zone. Alarming monitors surrounding the excavation zone should be capable of detecting small releases. An alarm would initiate work shutdown and suppression of the release. Further alarms placed within the tent, exhaust, and air lock will also initiate work shutdown and release suppression. This tent and monitoring system will ensure that there are no releases to the environment and will reduce worker exposure because of work shut down and release suppression.

The entire work zone (the entire Pit 9 or a substantial portion of it) can be enclosed with an air support tent. The air support tent would enclose the work tent, storage area, analysis modules, and equipment storage and decontamination. In addition to being a final point of monitoring and control, this tent will provide a well-controlled environment for both work and the monitoring and control equipment.

This basic design includes all the tasks to be performed and follows the requirements imposed. It is a simple proposal based on task analysis and qualitative risk analysis. A final design would be more detailed. The design approach should be to keep all systems simple and flexible. Refinements to the design should be developed on a risk-based method that considers the expected conditions and effects of each task. Provisions to the design should consider methods to deal with worst case situations.

The current Stage II design follows the principle of maximum containment of the maximum, continuous worst case conditions, but does not consider tasks and control at the source. The totally remote and contained design complicates each event and thereby increases the opportunity for mistakes. The remote retrieval system requires that all operations are performed overhead of the excavation rather than the most convenient angle or approach. The system appears to be designed to retrieve drums when no drums are expected to be intact.

7. Evaluation of Stage II Waste Handling versus Risk Based Needs for Personnel and the local environment

The Stage II design has incorporated waste handling for inspection, repackaging, and shipment within the excavation module. A single unit is attractive for fully containing the operation as a fixed facility. A more cost effective design might be modular handling cells that are truck or skid mounted that are tailored to the activity performed. These cells could be placed within the large air structure for secondary containment. The cells can be constructed from easily decontaminated materials and have integral monitoring and handling equipment.

Transfer from the excavation and between cells could be with prescribed containers designed for easy entry but well secured during transport.

8. Conclusions and Recommendations

The Stage II system is excessively over designed and analyzed. No consideration was given of actual risks and how to reduce them with simple means. Two retrieval study reports (Thompson 1972, McKinley 1978) show that retrieval is possible with little contamination spread. The reports note that some waste forms and condition of waste forms could result in contamination spread if improperly handled. No consideration was given to using the same techniques of the two reports with modification to prevent contamination spread.

It is recommended that Stage II incorporate an excavation based on Thompson 1972 and McKinley 1978 with risk-based modifications for various waste types and conditions.

9. References

1.) Thompson, R. J., Solid Radioactive Waste Retrieval Test, Allied Chemical Corporation, ACI-120, May 1972.

2.) McKinley, K. B. and J. D. McKinney, Initial Drum Retrieval Final Report, EG&G Idaho, TREE-1236, August 1978.

3.) Independent Technical Review of Proposed Drilling Activities for Operable Unit 7-10 Stage Interim Action [Alternative Pit 9 Project], September 1999.
4.) Pruvost, N. L., and H. C. Paxton, Nuclear Criticality Safety Guide, Los Alamos National Laboratory, LA-12808, September 1996.
5.) Oztunali, O., I., G. C. Re, P. M. Moskwitz, E. D. Picazo, and C. J. Pitt, Data Base for Radioactive Waste Management, Impacts Analysis Methodology Report, NUREG/CR-1759, Vol. 3, 1981, Page A-9
6.) Section 3.3.4 Human Factors – Pit 9 retrieval equipment shall be remotely operated. OU-7 Staged Interim Action Project System Requirements Document, Rev. 2, 27 April 2000